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No. 248

SPECIALIZING FOR RECORD-BREAKING.

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1215 SIXTH STREET, N.W.
WASHINGTON, D.C.

February, 1924.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL MEMORANDUM NO. 248.

SPECIALIZING FOR RECORD-BREAKING.*

By Edward P. Warner.

When the value of an airplane record to the companies engaged in the manufacture of airplanes becomes great enough, whether for advertising or through the direct offer of financial reward, to stimulate real competition it is certain that special designs will be prepared and that airplanes will be built with the attainment of an absolute maximum of performance in some one particular as the sole aim. The history of the Pulitzer race, America's present aerial speed classic, well illustrates that tendency. In 1920, when the first competition was held, only one of the competing airplanes had been built primarily for the race. The next year, at Omaha, there were enough real racing airplanes entered to form a majority of all the entrants, and in 1922 and 1923 not a single pursuit airplane, nor any other designed with any important idea except speed, came to the starting line.

The same will be true of altitude and duration, and has, indeed, already been true there to some extent, as well as of speed. It is of interest, then, to see what determines airplane performance and what line should be followed in seeking to break records if the designer is given a free hand.

* From Christian Science Monitor.

There are various ways of calculating performance, and they vary in complexity, as in accuracy. For the present purpose, at least in dealing with the broad outlines of the problem, approximate formulas involving only a few of the most important dimensions and characteristics of the airplane, and not including the particular form and disposition of the parts, would be most useful.

Ratio of Engine Power to Wing Area.

Such formulas show that the maximum speed of a fast airplane is, within reasonable limits, virtually independent of the total weight carried, being governed only by the ratio of engine power to wing area and rising as that ratio rises. The speed can then be increased, generally speaking, by raising the power or clipping the wings. Both of those processes have been carried to extremes, the former to a point where the whole airplane, loaded and ready for flight, weighs only five pounds a horsepower and is very nearly capable of lifting itself vertically as a helicopter, the latter to such a degree that some of the racing airplanes have carried nearly 20 pounds a square foot. Landing speed is dependent on the weight carried per unit of wing area, and such a loading as this implies making contact with the ground at some 90 miles an hour. The search for speed by reduction of wing surfaces has been pushed relentlessly toward its logical development only in Europe, however, for the Pulitzer race rules provide that competing airplanes must be able to land at under

75 miles an hour. Were that provision annulled, maximum speeds could be still further raised, but the hazard would be increased and the gap between racing airplanes and those of direct practical usefulness would be still further widened, and it is to be hoped that the rule will stand as it does now.

If minimum speed is to be fixed the wing loading for a given wing section is limited, and the area can only be reduced by reducing the weight. Total weight, once thrust aside as of no importance, therefore returns as a factor of considerable, although indirect, moment under the Pulitzer rules, and the first object of the designer, in conjunction with those responsible for the power plant, is to cut the weight per horsepower to the lowest possible figure.

Minor Refinements.

That done, minor refinements claim the attention. Every projecting element capable of adding, however slightly, to the resistance is eliminated, perhaps even to the extent of folding the wheels and their struts back within the fuselage. A search for the best wing section is conducted, and at the present time the choice usually falls on a very thin form with nearly flat or slightly convex lower surface, but there are signs that that may not long continue to be the case.

Of all new inventions to increase speed, the most valuable would be an engine of reduced sectional area and accordingly of less head resistance than the existing forms, and a wing of

which the lifting power could be varied while in flight by changing the area or otherwise, thus making it possible to secure a high lift for landing at a moderate velocity and to cut it down for efficient flight at very high speed. Neither variable-lift wings nor engines of radically new type and reduced area have as yet appeared in the Pulitzer race, but both are likely to do so within the next three years.

The quest for altitude involves weight, power, and wing area, but the three are not of equal importance. Roughly speaking, the relative effects are in the ratio of 3, 2, and 1, a decrease of 2 per cent in weight, an increase of 3 per cent in power, and an increase of 6 per cent in area raising the ceiling by the same amount. It will be noted that the effect of wing area on climb is of an opposite nature to its influence on lift, benefit accruing from an increase in one case, from a decrease in the other.

In actual practice, however, it does not pay to try to use a very light wing loading in airplanes designed to break altitude records, for any increase of area necessarily involves an increase of weight, and the loss due to that increase balances the gain from the change of loading.

Low Wing Loading.

Altitude, like speed, therefore becomes very largely a matter of weight per unit of power, but it must not be supposed from that that altitude and speed airplanes tend to become identical. The

desirability of at least a moderately low wing loading when high ceilings are sought is never quite lost from sight, and the secondary considerations in the two cases draw the designer in quite different directions. While the reduction of the resistance of wires and struts and body is paramount in designing racing airplanes, in working for great altitudes the efficiency of the wings is more important. Thicker sections are used, and the aspect ratio is likely to be much higher than it would be if only speed were in question. Although biplanes have held the altitude record for many years now there is no apparent reason why a monoplane should not regain it, for the merits of the two types for this service are closely matched.

More important than anything that the airplane designer can do to add a few hundred feet more to the ceiling, however, are the endeavors of those responsible for the engine and its accessories. Some engines would not run at all at heights as great as those which aircraft are now reaching, and further improvement in the altitude record will be largely a matter of improvement in the technique of maintaining engine power at low air densities. The drop of power can most readily be averted by using a supercharger, and altitude records in the future will be held by the nation which has produced the most efficient supercharging equipment. Airplanes already exist which would be easily capable of climbing to 60,000 feet if there existed a supercharger which would hold the engine power constant at its sea-level value at altitudes as great as that, but no such auxiliary now used is

capable of preventing all loss of power at heights much, if any, in excess of six miles.

Duration.

Turning finally to duration, the third of the principal records, the problem of designing for improved performance is found to be largely a structural one. To stay in the air for the greatest possible time, the largest possible proportion of the initial weight must be in the form of fuel, and the structural weight must therefore be reduced to a minimum. In general, that requirement would indicate a biplane with a thick wing section and a moderate amount of external bracing, although the duration record at present is held by an internally-braced monoplane. It is also important that the overall efficiency be made high by the selection of a wing of good aerodynamic qualities and by omitting from the structure such resistance-contributing members as can be spared, and a light wing loading would be desirable were it not that here, as in respect of climb, enlargement of the wing adds to the structural weight which must be carried. Here again, therefore, a compromise has to be arrived at.

The duty of the engine designer in connection with the making of a duration record is to furnish a light engine, reliable enough to run through the forty-hour period of the flight with certainty, and with a very low fuel consumption under all conditions of operation. The last clause is very important, since

the engine will always be throttled down so that it is just possible to remain in the air, and an engine may be very economical at full speed and full load and yet show a relatively high consumption when throttled.

There has, up to the present time, been relatively little special designing for altitude or duration, and those records have been held by airplanes originally intended for ordinary service. There can be little doubt, however, that as competition becomes more intense, and as the constructors of the several great nations come into direct conflict in seeking export business among the smaller states, the effort to secure and hold records will grow even keener, and that will lead to the development in every field of a special technique of design analogous to that already developed for the racing airplane and now leading that type to something approaching standardization. The fundamentals here summarized in broad outline will then become the subject of intensive study by designers.